Small Inertial Measurement Units - Sources of Error and Limitations on Accuracy

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inertial measurement units (IMUs) with very low mass and power can be manufactured using micromachined accelerometers and g yroscopes. Six degree of freedom packages which require a few watts of power and have less than a kg of mass are available commercially, greatly expanding the potential applications of IMUS in guidance and navigation. Recent advances in small sensor design and fabrication have pushed the performance limits of these small devices. However, the limitations on the precision of small IMUs are not entirely due to the performance of the individual sensors. In this paper, the potential precision of position measurements obtained by integrating IMU data is considered with respect to the precision of IMU sensors and the effects of environmental noise. Environmental sources of potential errors in the IMU measurements include coriolis and centrifugal forces caused by rotation of the Earth, position dependence of the Earth's gravitational field, tidal forces due to the Earth's moon, and seismic noise. Sensor limitations include axis misalignment in the IMU package, electronic noise, thermal noise, cross sensitivity, temperature and pressure dependence of the calibration, and calibration accuracy of the sensors. As IMU data are integrated from the initial conditions to determine the position and orientation as a function of time, errors accumulate. These cumulative errors limit the total integration time over which the IMU data yield sufficient accuracy in the calculated position. This time limit for integrating IMU data is such that most practical applications of small IMUs will require a secondary position measurement system to periodically update the initial conditions.

Michael E. Hoenk is a Member of the Technical Staff at the Jet Propulsion Laboratory, California Institute of Technology, where he has been employed since 1990. He received a Ph.D. in Physics from the California institute of Technology in 1990, where he studied quantum confinement effects in III-V semiconductors. His research interests arc in the areas of semiconductor materials, silicon micromachining, and sensor technology. He recently demonstrated the first epitaxial growth of silicon on backside-thinned CCDs, which resulted in a measured 100% internal quantum efficiency throughout the near ultraviolet. His current focus is on the development of low-mass, low-power pressure, temperature, humidity, and wind sensors for *in situ* weather measurements in the Earth's upper atmosphere and in the Martian planetary boundary layer.